APPENDIX F
WATER QUALITY CRITERIA AND STANDARDS PRESCRIBED BY THE WASHINGTON STATE DEPARTMENT OF ECOLOGY

Surface Water Hydrology

Elliott Bay Subbasin

Elliott Bay exhibits typical estuarine behavior, with the inflow of more dense saline water at depth and outflow of fresh or brackish water at the surface (Sillcox et al. 1981). Currents in Elliott Bay are influenced by a number of factors: semi-diurnal tidal exchange, fresh water input from the Duwamish River, and wind effects. Within Elliott Bay, the mean tidal range is 11.3 feet (3.44 meters), and currents are generally weak (< 2 inches [5 centimeters]/second). In the outer bay, circulation is closely associated with the main basin, resulting in a typically counterclockwise, mid-depth sub-tidal flow; in the inner bay, currents are weaker and are less influenced by the central Puget Sound basin currents (McGary and Lincoln 1977; Sillcox et al. 1981). Water predominantly flows into the bay at depth and outward near the surface (Sillcox et al. 1981). Surface salinity and temperature indicate that the Duwamish River plume is located on the north side of the bay year-round (Sillcox et al. 1981). Tidal currents run south on a flood tide and north on an ebb tide during spring tides, but are weak and erratic during neap tides (King County Metro 1995b).

The Duwamish River is a significant source of fresh water entering the south end of Elliott Bay. Because of the density difference from sea water, this fresh water forms a “plume” floating on top of the sea water. Recently conducted studies indicate that this plume flows parallel to the shoreline northward out of inner Elliott Bay. However, because the plume is shallow it is subject to wind influences. Winds from the north can drive the plume into southern Elliott Bay, while winds from the south drive the plume north along the waterfront (Evans-Hamilton 1996).

Beneath the Duwamish plume, a thick layer of sluggish water comprises the major component of flow in Elliott Bay. This flow layer, which extends to a depth of approximately 150 feet, is several orders of magnitude greater than the upper flow layer, and represents flows diverted from the main basin of Puget Sound. This flow layer moves primarily in response to tides and the main basin’s average currents.

The third layer of flow is the deep layer, extending to depths greater than 150 feet. These currents tend to follow bottom contours, essentially entering Elliott Bay through canyons. In this layer, currents tend to be influenced by irregularities in the shape of the bottom topography.

Surface Water Quality

South Lake Union Subbasin

Temperature/Dissolved Oxygen. Lake Union is seasonally stratified, with temperatures ranging from around 43 degrees Fahrenheit (ºF) (6 degrees centigrade [ºC]) temperature throughout the water column in the winter to 66º F to 73º F (19º C to 23º C) in the surface waters during the summer. Bottom waters generally do not exceed 59º F (15º C) in the summer. Dissolved oxygen ranges between 8 and 12 milligrams per liter (mg/L) (lower) at the surface during the year and between 0 and 12 mg/L in deeper waters. The depth region in Lake Union typically lacks oxygen during the summer (July to September). Oxygenation of surface waters is at or near saturation throughout the year. Mesotrophic lakes, such as Lake Union, typically lack oxygen at depth for all or part of the summer to fall (Wetzel 1983; Hansen 1994).

Productivity. Lake Union has been classified as mesotrophic (moderately enriched) according to chlorophyll concentration, phosphorus concentration, secchi disk transparency, and phytoplankton community structure (Montgomery and Entranco 1987; Metro 1991). Chlorophyll concentration (a measure of algal productivity) ranges between 2 and 10 micrograms per liter (µg/L), with a long term median of 4 µg/L (Hansen 1994). Total phosphorus concentrations generally range between 15 and 30 µg / L (Hansen 1994). Nitrate and ammonia concentrations are high in the winter, and decrease during the summer until they are below detection limits in surface waters (Hansen 1994). Ammonia builds up in the summer in anoxic bottom waters (Tomlinson et al. 1977). There has been no apparent long-term trend since the mid-1970's in phosphorus or nitrogen concentrations (Hansen 1994).

Metals. The concentration of metals in the water column is generally low in Lake Union. Total copper concentrations have exceeded the state freshwater acute toxicity criteria on a limited number of occasions, and total cadmium, copper, lead, and zinc concentrations have periodically exceeded the state freshwater chronic toxicity criteria (Metro 1987). Acute criteria apply to infrequent discharges or intermittent sources; chronic criteria are long-term exposures.

Organics. Organic compounds such as polychlorinated bipheyls (PCBs), PAHs and phthalates have not been extensively monitored in the Lake Union water column. Organic compounds (phenol and benzoic acid) were detected at low concentrations at three sites in 1990, and PAHs and phthalates were detected at low concentrations near Gasworks Park. No state or federal freshwater criteria for PAHs are currently available.

Fecal Coliform. Fecal coliform bacteria frequently exceed the state lake water quality criterion of 100 organisms per 100 milliliters (mL) during months with high precipitation (Hansen 1994). There is high spatial variability in fecal coliform concentrations in Lake Union waters. South Lake Union generally has lower fecal coliform concentrations than other sites closer to or in the ship canal. Periodically, high concentrations of fecal coliform bacteria have been attributed to CSO and stormwater discharge events (Metro 1990). Since 1979, Lake Union as a whole has regularly exceeded state water quality standards from November through February (Metro 1993b).

Elliott Bay Subbasin

Temperature/Dissolved Oxygen. In summer, the water column is thermally stratified and maximum surface temperatures of 57º to 59º F (14º to 15º C) occur in August, while bottom temperatures do not increase above 52º F (11º C). Winter temperatures remain relatively constant between 43º to 46º F (6º C and 8º C). During winter and spring, river discharge is high, and surface waters in the Duwamish plume (north side of the bay) exhibit relatively lower salinities than the rest of Elliott Bay. This effect is reduced during the summer (Sillcox et al. 1981). Dissolved oxygen concentrations tend to be highest in the spring (10 mg/L), coincident with maximum phytoplankton production. Lowest dissolved oxygen concentrations typically occur in the late summer and early fall, resulting from reduced productivity, decomposition of phytoplankton, and intrusion of low-oxygen oceanic water into the central basin. During the late summer and early fall, near-bottom oxygen concentrations can fall below the water quality standard of 6.0 mg/L.

Productivity. Elliott Bay has relatively low productivity for floating algae and aquatic plants compared to many areas of Puget Sound, because high concentrations of suspended solids contributed by the Duwamish River interfere with light transmission (Stober and Pierson 1984). Although nitrogen is generally limiting for phytoplankton productivity in marine waters, Elliott Bay and Puget Sound are limited by the available light (Welch et al. 1972). Therefore, chlorophyll concentration in Elliott Bay is generally less than 1 µg/L, except during periods of low river discharge and high water column stability (Stober and Pierson 1984). The bay exhibits a thin (<16 feet [<5 m]) surface layer of suspended matter which is dominated by phytoplankton in the summer and inorganic particulates in the winter.

Metals and Organics. As part of the *Draft Water Quality Assessment* for King County, EVS Consultants (1995) identified a number of water quality contaminants of concern associated with CSOs. These contaminants included nine metals and four organic compounds; these are included in Table F-2 . These contaminants of concern were selected based on their frequency of detection in CSOs, environmental persistence, toxicity, biomagnification potential, regulatory status, measured concentrations, and other factors.

Despite the prominence of the highly urbanized Seattle Waterfront in Elliott Bay, toxic metals contaminants are found in relatively low concentrations in surface waters (Stober and Pierson 1984). Only zinc and iron were found regularly in surface waters at greater than 1 µg/L. Lead, chromium, nickel, and copper were all present, but were found at very low concentrations in the water column. Recent evaluations by King County Metro (1995b) indicate that organic constituents in the water column are very low (below the threshold of risk to aquatic organisms).

Fecal Coliform. The concentration of fecal coliform bacteria in Elliott Bay is generally low, except in the winter months (Metro 1994). Fecal contamination in intertidal areas appears to occur during periods of high rainfall when river discharge and CSOs are at maximum flows (Metro 1994). However, fecal coliform contamination is generally correlated less with location and more with exposure. Those beaches that are exposed to wind and waves tend to have lower levels of fecal coliform bacteria (Metro 1987; Metro 1994). Regardless of beach location, the Seattle-King County Public Health Department does not recommend collecting shellfish for consumption from any urban marine beach (Metro 1990).

Although beaches on the Seattle waterfront tended to exceed state shellfish growing standards during the winter months, offshore water column monitoring has shown relatively low fecal coliform bacterial contamination. Offshore stations exceeded standards less than 1 percent of the time in subsurface waters. In addition, monitoring near sewage outfalls has shown a steady, but non-significant, decline in fecal coliform bacteria levels since 1980 (Metro 1987; Metro 1994).

Table F-1
Water Quality Criteria and Standards Prescribed by the Washington State Department of Ecology
WAC 173-201A-30 (effective 12/26/92)

Classification	Fecal Coliforms	Dissolved Oxygen	Temperature	pH
Lake	Mean < 50 per 100 mL ≤ 10 percent of samples exceed 100 per 100 mL	No measurable decrease from natural conditions	No measurable change from natural conditions	No measurable change from natural condition
AA (Freshwater)	Mean <50 per 100 mL Maximum < 100 per 100 mL	Greater than 9.5 MG/L	Less than 61° F (16° C)	Between 6.5 & 8.5
AA (Marine Waters)	Mean < 14 per 100 mL < 10 percent of samples have more than 43 per 100 mL	Greater than 7.0 MG/L	Less than 56° F (13° C)	Between 7.0 & 8.5
A (Marine Waters)	Mean < 14 per 100 mL < 10 percent of samples have more than 43 per 100 mL	Greater than 6.0 MG/L	Less than 61° F (16° C)	Between 7.0 & 8.5

Source: WAC 173-201A (Ecology 1992).

Table F-2
Contaminants of Concern

Inorganic Substances	Organic Compounds
Arsenic	Benzoic Acid
Cadmium	Total PAHs
Chromium	Butylbenzyl phthalate
Copper	Bis (2-ethylhexyl) pthalate
Lead	
Mercury	
Nickel	
Silver	
Zinc	

Source: EVS Consultants 1995.